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FLIGHT REPORT
SKYCAR FLIGHT NO. 797
13 AUGUST 1958
Contract AF 29(600)-1553

Report No. 1241-R

Prepared for: Aero-Medical Field Laboratory
Air Force Missile Development Center
Holloman Air Force Base
New Mexico

Prepared by: Otto C. Winzen

Date: 20 September 1958

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I. INTRODUCTION

The ill-fated Sky-Car Flight No. 797 was intended to qualify Captain Grover Schock as a balloon pilot under existing CAA regulations. O. C. Winzen was the pilot instructor. After a fine flight, the last landing resulted in a crash, described in detail. At the date of this writing, both pilots are recovering satisfactorily in hospitals and expect to be released about the end of this month.

As a result of the crash landing, two other pilots are being prepared for the MANHIGH III flight. They are Lt. Clifford M. McClure and Captain Harry R. Collins.

This report is illustrated with photographs and charts, and has three appendices.

II. EQUIPMENT

Balloon - 45' diameter, 49,200 cubic foot volume.

Configuration - Sphero-conical with 90° included angle.

No. of gores - 16, red and white alternating.

Material - Double-wall 1.5 mil gage polyethylene DE 2500 A film, opaque white and opaque red.

Valve - WRI 14" diameter mechanical valve with manual actuation by means of a 500-pound nylon line to the gondola.

Suspension harness - 32 lines of 1000-pound nylon lines terminating in parachute quality D ring.

Inflation tubes - side inflation, 10" layflat by .004" opaque red tied off after inflation.

Load bands - 32 500-pound test integrally heat-sealed load bands.

Construction - WRI filament stressed (FIST) construction.

Parachute - 70' diameter extended skirt, 1.1 oz. ripstop nylon, red and white, terminated in six risers attached to the webbings that lead to the gondola.

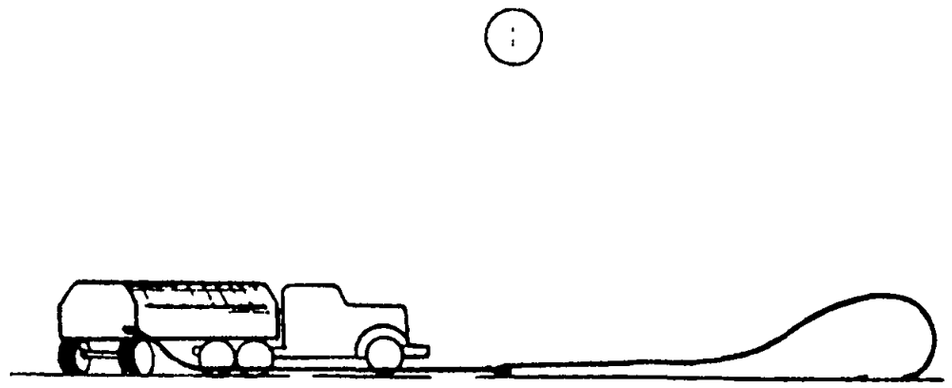
Gondola - WRI Sky-Car I, 4-1/2' diameter, equipped with flight instruments and communications equipment (reference WRI Technical Report No. 4A).

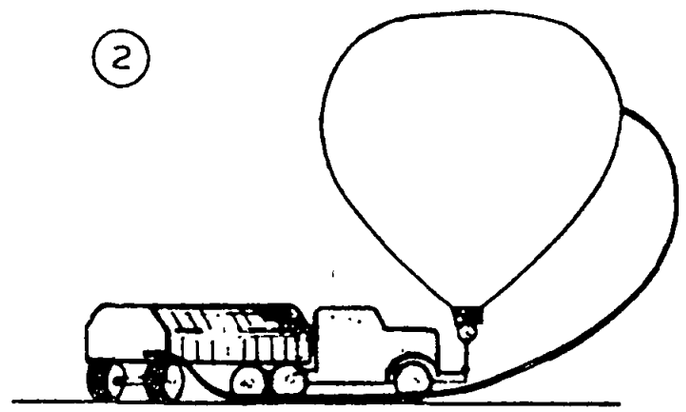
III. PROCEDURE

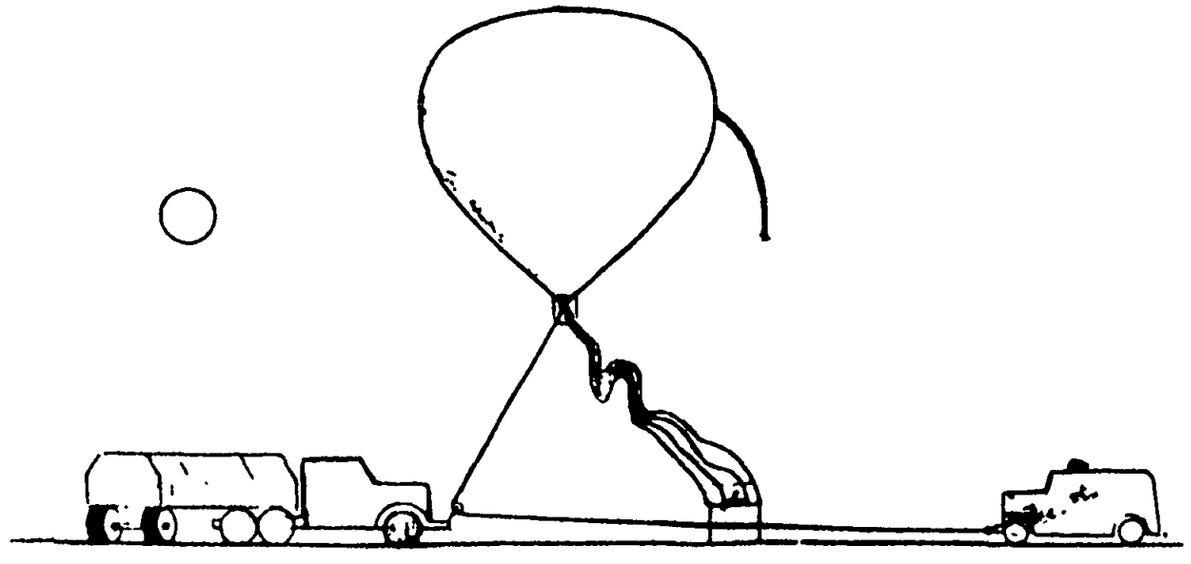
In order to qualify a student pilot for his solo flight before a CAA inspector, it is necessary that he conduct a total of 8 landings, accumulate 16 hours of flight time, and conduct one flight to 10,000 feet altitude. The objective of this flight was, therefore, to have Captain Schock conduct a minimum of 6 landings, accumulate as much flight time as possible, ascend to 10,000 feet altitude, and demonstrate to the instructor's satisfaction his proficiency in handling the aerostat. Captain Schock successfully completed all preliminary requirements except that of flight time, which it was felt he could make up on his final solo flight.

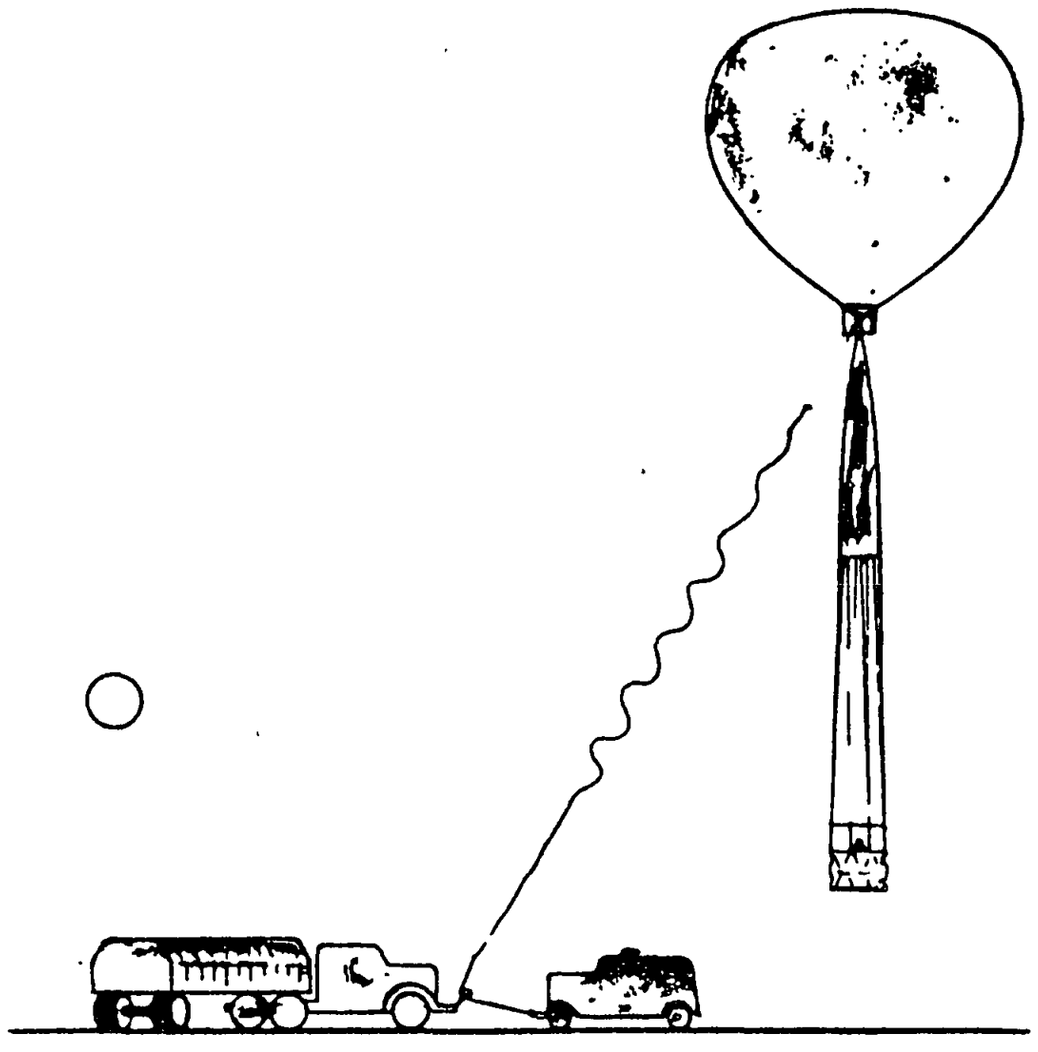
In view of the relatively high wind velocity (20 miles per hour and up), the interim landings consisted of touching down with the drag rope of 75' length. In view of the flight direction, suitable landing sites were far apart because of the heavily wooded area which was crossed. However, the necessary number of touchdowns (6) were made with the student pilot conducting all operations including ballasting and valving. (In the launchings of WRI Sky-Car flights, the launching crew is responsible for the launching. See Drawing W-1086-C.) Photo 662-23 shows the configuration of a typical WRI "Sky-Car" aerostat with balloon, open parachute, and suspended gondola. At the moment of landing the balloon is cut away by the pilot electrically, actuating an explosive cannon device which separates it from the apex of the parachute.

On flights of this type, depending on conditions, hourly or half-hourly radio contacts with the tracking crew, nearby CAA or Unicom stations and the WRI plant, if within range, are accomplished.









W I PROJECT SKY CAR

WINZEN RESEARCH INC MINNEAPOLIS 20 MINNESOTA
FLEMING BLD SOUTH ST ST. PAUL, MINNESOTA

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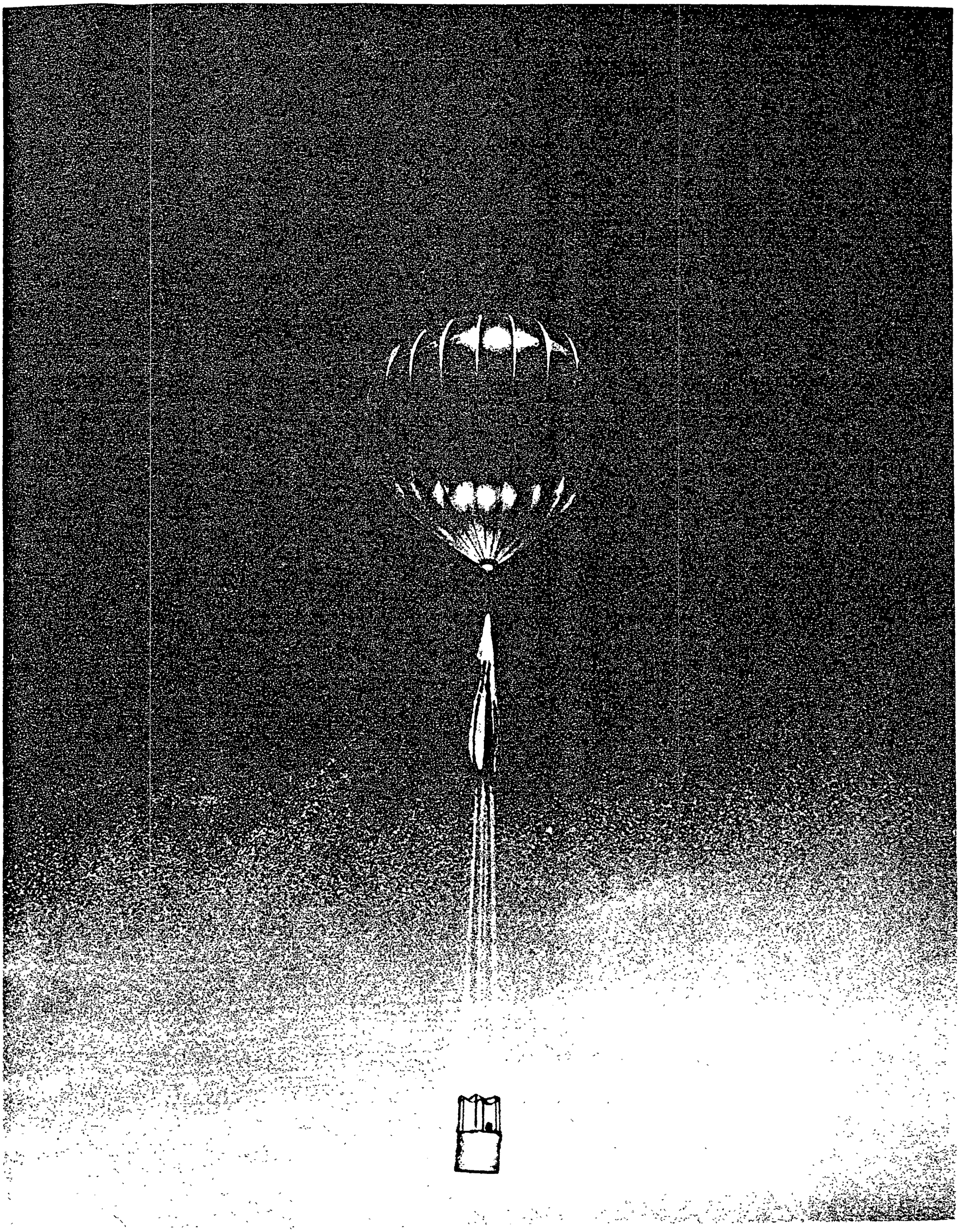

662-23 Winzen Research Inc. Sky-Car at the moment of launching. The balloon is a 31.5 ft. dia. N.S. constructed of 2 mil

The enclosed Flight Report lists pertinent technical data of the flight.

WINZEN RESEARCH INC.

8401 LYNDALE AVE. SO.
MINNEAPOLIS, MINNESOTA

BALLOON FLIGHT REPORT

Flight No. 797 Date: 13 August 1958 Time: 0730 CDT

Project No.: AF-496 Flight For: Aero Med Field Lab (MANHIGH III)

Scientific Payload: Sky Car gondola w/crew Weight: 2053

Scientific Purpose: Pilot training flight

Scientific Success: ---

BALLOON DATA

Manufacturer: Winzen Research Inc. Size: 45' x .002" Serial No.: 45-200-V-219

Type: SC, "FIST" construction, 32 load bands (500#), 14" manual valve skirt app. Weight: 139

LAUNCHING DATA

Launching Site: Fleming Field, So. St. Paul, Minn. Launching Method: Vertical

Wind: SE 2 knots Sky: Scattered cirrus (3/10) Temperature 60 °F

Total Payload: 2136 # Free Lift -- % ------ # Gross Inflation: 2275 #

FLIGHT DATA

Max. Altitude: 11,800 MSL Theoretical Altitude: 11,670 MSL

Flight Duration: 10 hours, 50 minutes Altitude Maintenance: Controlled

Ballast: p265# Rate of Ascent: Variable

Landing Site: 1 mile SW Ashland, Wisconsin Recovery Time:

Balloon Performance: Excellent Balloon Landing Site: Lake Superior

FLIGHT RESUME

See detailed report by Otto C. Winzen

IV. THE FLIGHT

CAA was notified of the impending launching, and when the WRI flight crew under M. L. Lewis had completed the balloon inflation and prepared the gondola, Captain Schock and O. C. Winzen boarded the gondola, tested the valve, set the clock, altimeter, and checked all instruments including radio. The launch took place at 0730 CDT from the WRI balloon flight center at Fleming Field, South St. Paul, Minnesota.

At the request of the Air Force Public Information Officers present who had brought with them a number of photographers and representatives of the press, a pseudo-landing was made at Fleming Field. The gondola was weighed off slightly heavy, was boosted aloft by the WRI flight crew, then executed a landing approximately 100 feet downwind, after which by careful expenditure of ballast the aerostat rose slowly. While being photographed from the ground, the pilots took photographs of the launching crew and photographers. The weather forecast called for ideal conditions for the rest of the day. This later proved to be false.

At first the aerostat took a course toward the Twin Cities. While in their control zone, the Minneapolis Tower and CAA Communications were contacted and advised of the balloon's position at half-hour intervals so they could notify aircraft in the vicinity.

The aerostat was permitted to continue rising so that by 0800, the start of the workday at the WRI plant, contact could be made with company headquarters (NCA-31). This was accomplished at 0800, but for some time contact with tracking vehicles could not be established.

As the aerostat rose, its course shifted from northwest to northeast. Having made contact with NCA-31, it was no longer considered necessary to fly at such high altitude, and a descent was begun at 0810. At 0930 contact was established with both the plant and the tracking vehicle, and shortly thereafter Stillwater, Minnesota, was passed one mile to the north. From then on began the most scenic portion of the flight since the balloon followed the course of the upper St. Croix River very closely. Descending to an altitude of approximately 100 to 200 feet above the ground, there were conversations with fishermen, while also keeping in touch at half-hourly intervals with the tracking vehicle and the plant.

At 0953 at an altitude of 2600 feet MSL, two swallows were seen circling the balloon. The writer has observed this phenomenon on a number of occasions. This time, unlike other times, the birds made no attempt to hang onto the balloon or the inflation tube.

Not until 1020 was the first touchdown made near the St. Croix River approximately 10 miles north of Stillwater. A total of 15 pounds of ballast was required to reestablish the ascent. Ten minutes later a second touchdown approach was made approximately 12 miles north of Stillwater. Only 10 pounds of ballast was expended to reestablish ascent at this time.

Still hugging the St. Croix River, the aerostat passed over Osceola, Wisconsin, at 1800 feet indicated altitude, or approximately 800 feet above the terrain. The spectacular scenery of the St. Croix Valley

continued. Captain Schock was instructed to keep the flight log, and this log with its time reference and brief notations is included herewith as Appendix I.

Ground speed had by now been determined to be on the order of 20 miles per hour even when flying at a ground clearance of only 100 feet. Since a cloud build-up on all sides was now visible, weather information was requested from the plant. It was deemed advisable in view of the cloud build-up no longer to delay the ascent to 10,000 feet, as otherwise there might be interference from thunderheads and rain. Thus, at noon, the ascent was begun by expending ballast on several occasions in order to rise at a rate in excess of 200 fpm. At 1230 the Duluth forecast indicated scattered rain showers and thunderstorms for the afternoon, 8 knots of surface wind by sunset, while the current wind velocity on the ground was approximately 20 miles per hour. The WRI plant advised to watch shower activity closely and terminate by 1800 in any event. We were also informed that a second tracking crew including the Air Force physician, Dr. Ruff, had left the WRI plant.

It was necessary to expend ballast repeatedly in order to continue the ascent. By this time, high towering clouds had formed on all sides, but the balloon avoided going through clouds. At 1330 an altitude of 10,000 feet was reached. It was found equally difficult to begin a descent so that by 1346 a maximum altitude of 11,800 feet was recorded in the log. The pilot took a photograph of Captain Schock next to the instrument panel, recording this altitude. By 1400 the balloon had begun a definitive descent and the crew again concentrated on navigation. The scenery visible between the clouds revealed many lakes and an almost continuous

expanse of forest and hills, not the type of country suitable for landings. Then by 1447 the cumulus clouds overhead began to burn off as quickly as they had formed. Many of them had been of the towering kind, some had appeared so black that they seemed to hold rain.

At 1450 the third touchdown was made near Birchwood, Wisconsin, and at 1500 the fourth touchdown near Stone Lake, which town was passed at an altitude of 3200 feet MSL at 1525. At 1530 the fifth touchdown was made on the other side of Stone Lake, Wisconsin. Clouds were again building fast.

Seven minutes later the balloon was surrounded with light rain and there appeared a full rainbow. At 1600, over Hayward, Wisconsin, the Muskellunge fishing capital of the world, the crew had an opportunity to review from the air the many lakes in which these fish make their habitat.

By 1620 contact with the Unicom station at Cable, Wisconsin, was established, requesting that station to call the WRI office collect to relay position, altitude, etc. Their local forecast was for 15 - 16 mile-per-hour winds from 210 to 240 degrees until evening. (It should be stated here that surface winds are not necessarily indicative of the landing speed of an aerostat inasmuch as the highest point of the balloon - in this case approximately 175 feet above the ground - is the criterion for the wind velocity. Thus, it is the wind velocity at the apex of the aerostat which governs the landing speed rather than the wind velocity taken at the surface. Experience had indicated that velocity was in the neighborhood of 20 miles per hour.)

It was decided to ascend to an altitude of 5000 feet in order to facilitate communications with the tracking crew who seemed to have difficulty keeping up with the aerostat in this trackless terrain where roads are far apart and which is essentially a wilderness. It was determined that ground speed was still 20 miles per hour regardless of altitude. By 1640 Cable reported winds at 12 knots from 208 degrees, but again this was taken with considerable doubt because of the Cable terrain and the fact that the winds were taken near the surface. They reported the Duluth weather forecast for sunset as follows: "8 to 12 knot winds from 180 degrees, thunderstorms after 2000."

It was felt that their forecast was somewhat optimistic inasmuch as the balloon had been paralleling, for the last half hour, a thunderstorm approximately 1 mile to the West. In fact the first thunder and lightning were observed at 1700. Fortunately this storm did not seem to approach any closer and there appeared no immediate necessity of accelerating the landing.

Because of the difficult terrain, advice was requested from the Cable Unicom operator regarding the type of terrain between our position and Ashland, Wisconsin, the town for which the balloon seemed to be heading. Cable advised to land north of Mason, Wisconsin, since there was no possible landing site between the current position and that town.

Captain Schock's log ends at this point. From then on the crew was preoccupied with finding a suitable landing place prior to being driven out over Lake Superior in a direction which would have carried the aerostat

the length of the lake and into the Canadian wilderness. It was therefore decided to terminate the flight before reaching the lake.

The sixth landing was attempted approximately three miles from the edge of Lake Superior between Mason and Ashland, Wisconsin. It had become apparent that it was not possible to count on the tracking crew to be at the landing scene because of the high air speed and their inability to reach a landing site prior to our arrival there. The building of the thunderstorm to the north and west now gave reason for concern. The sixth landing attempt had to be aborted inasmuch as the gondola was headed for a fence and electrical high lines.

During this last ground approach it was determined that an unusual landing condition existed. (Captain Schock had by this time learned that balloon flying is an art rather than a science; also that for the balloon pilot of today, many hazards have been added to those known to the old aeronaut. There are airplanes to look out for since pilots sometimes do not watch ahead. Then the REA and the telephone company have done an effective job of stringing their high-lines, until in many areas it seems impossible to find a field which is not neatly encircled. Further, the writer has been shot at on 2 flights, 4 bullets passing through balloon and parachute in one case.) During the last approach either due to the vicinity of the thunderstorm and its vertical air currents, or due to a super-adiabatic lapse rate, the descent velocity increased continuously from 100 to 300, 600 and 700 fpm and had to be compensated for by excessive expenditure of ballast. This was demonstrated and mastered and a successful landing could have been made had it not been for ground obstructions.

With some misgivings, a renewed ascent was made in the hope of finding one more field before reaching Lake Superior. This opportunity availed itself within approximately one mile of the shore, and a controlled approach was made despite the same difficulty of rapidly increasing descent rates. Ballast was expended judiciously to overcome this tendency and maintain a rate of descent of approximately 100 fpm. The field toward which the aerostat was headed was not very large, but the approach toward it was normal in every respect. The valve line was now cut free. Both pilots were in good spirits, there was no feeling of premonition or of nervousness.

V. THE FINAL CRASH LANDING

Anticipating a hard landing due to the 20 mile per hour wind, Captain Schock and the writer were strapped down in our seat belts. During the flight, the various methods of landing were practiced. For hard landings, such as in high wind, the student pilot, seated opposite the writer, was instructed to be sitting down legs apart, strapped in his lap belt, and leaning forward approximately 30 degrees so that the force of the impact would jack-knife the torso forward and down relieving the spine from taking the impact in compression. Both pilots were assigned the direction in which to lean forward, as in the confined space of the Sky-Car I gondola they might otherwise hit their heads together. In contrast, for smooth landings with little wind, there is no hazard in standing up at the time of the landing, as is often done. In a wind of such high velocity, the writer anticipated a rough landing and possibly one in which the gondola might overturn. Therefore the precautions of carefully instructing Captain Schock in crash landing techniques. (Another reason for bending forward 30 degrees is to position the crew's heads below the edge of the gondola for protection in case the gondola should overturn.) In our standard balloon flight routine, the crew urinated into a plastic bag prior to the landing. This urine is used as ballast at the time of landing, as it was in this case. (It was not known at this time that this simple precaution might have saved our lives.)

At the pilot's orders, Captain Schock was expending ballast at a very high rate in order to maintain a 100 fpm rate of descent. The approach

into the field had to be made over a row of very tall trees. The final row of trees was cleared at about twice their height at which time our altitude was estimated at between 150 and 200 feet above the terrain. A moment after clearing the final trees, with the left hand the pilot took the knife from its sheath and cut free the long drag rope. Replacing the knife into the sheath, the pilot felt the sudden jerk of the line which indicated that the line had "hung up" and had not paid out smoothly. With his right hand reaching over to the instrument panel, the pilot opened the lucite shield which covers the critical controls. As he had done many times in the past, the pilot tried carefully to remove the safety cover from the cutdown switch, which is normally done at this altitude. Normally then, after the safety cover is removed, a few feet above the ground the right index finger is placed above the toggle switch so that the ground impact will cut away the balloon. But, on this occasion, things did not go according to their normal order.

Here is an exact sequence of events as the pilot recalls them very vividly:

1. As I carefully removed the safety switch cover with my right hand, the switch itself actuated and I heard the report from the cutter cannon in dicating that we had been cut loose from the balloon. I estimated our altitude at that time at approximately 120 feet and I knew this was not sufficient for the parachute to open.
2. My first thought was, "Well, this G---D------trigger-happy switch!" A rather silly thought under the circumstances.

3. I more or less automatically moved my right hand up to the handle bar. (Two such handles are located to the right and left to which the pilots hold on for a rough landing.) In placing my hand on this handle bar, I saw the tops of the trees going by at high speed.

4. At this sight my next thought flashed by, "This is the end, in a few seconds it will be all over."

5. Then suddenly I recalled the presence of Captain Schock, for whom I was responsible, and I shouted over to him, "Crash landing, get down, get down."

6. While I do not recall the impact as such, I do remember air rushing from my lungs as in an explosive decompression, several of which I had experienced in earlier Air Force training. This must have happened as my body slammed forward between my legs.

7. Subsequently, I must have lost consciousness for a matter of several seconds. I did not feel the impact nor the (more than likely) second bounce of the gondola as it hit the ground. The first thing I do remember is the gradual and painful straightening up from a bent-down position and Captain Schock opposite me doing the same, asking hoarsely, "What happened," and my breathed, dazed reply, "I don't know." I saw Captain Schock bleeding profusely from his chin. I felt no pain, just remorse at the thought of being responsible for eliminating Captain Schock as the MANHIGH III pilot.

By this time people were running toward us from all directions, and I urged them to take care of Captain Schock first to stop his profuse bleeding. I personally felt no pain. I saw my right hand, wrist and lower arm which had conformed themselves to the top of the radio case, and knew that it was broken in several places.

I knew I had many fractures. I recall Captain Schock being removed from the gondola and placed into a waiting ambulance. I recall how people tried to lift me from the gondola. I could not stand the pain, and they lifted me out by the seat which had broken off. Miraculously the gondola had remained upright when it came to rest. I remember in a half-dazed condition being put on a stretcher, into an ambulance, and rushed to a nearby hospital.

VI. CONCLUSIONS AND RECOMMENDATIONS

1. Relatively speaking, the modern plastic balloon, properly constructed, is a safe vehicle for low-level Sky-Car flights when they are made on ideal days. This is attested by the fact that many flights of this nature have been made without mishap.

2. In our large gondolae, (MANHIGH and STRATO-LAB) designed for stratosphere flights, there are two separate switches, which must both be actuated in order to effect the balloon release. The writer had personally made the decision that on the open Sky-Cars, a single switch with safety cover and a large lucite cover would be sufficient. This has since been corrected, and two switches have been installed on both WRI Sky-Cars for future flights.

3. It is recommended that the physical and medical data of this accident be made available to some authority in human deceleration experiments, such as Colonel Stapp, so that the nature of the impact and its results on two human bodies can be evaluated.

4. It should be stated here that the Sky-Car I was properly constructed for such an accident and through its design combined with the attitude assumed by the pilots contributed to the fact that the two pilots are still alive. The Sky-Car I is constructed of aircraft steel tubing. It has a 12" styrofoam pad underneath the floor designed to absorb impact (and provide floatation.) The seats consist of 3/4 inch plywood on cantilevered steel tubing

welded to the frame. At a given g-load they will break off, as they did in the case of the writer, whose side of the gondola hit first. Under the seats are battery cases filled partly with styrofoam, which once the seat breaks off contribute to the crushable mass below the pilot.

After the gondola had hit on the writer's side, it was given an angular momentum which contributed to moving Captain Schock's body to a more vertical position than had been the case for the writer whose movement was arrested also by his arms. Capt. Schock therefore cut his jaw on an aluminum frame which formed the top of the battery case under his seat. This injury could not have been caused by any other instrument since loose gear had been properly secured and stowed away in anticipation of a rough landing. From many standpoints the experience of the medical investigation and of the construction of the gondola may be useful in the design of future man-carrying re-entry capsules.

5. The accident, while regrettable from every standpoint, may have the useful purpose of pointing out that there are hazards connected with such flights, particularly the high-level flights, four of which WRI has now successfully completed. It should be noted here that each one of these flights is a tremendous enterprise and because a small though devoted company has been successful in conducting four such flights, this has perhaps beclouded the underlying fact that these flights are connected with grave dangers. In the past

every series of manned stratosphere flights with rubberized fabric balloons (1930 - 1935), came close to disaster or was disastrous. The amount of thought, the attention to detail, the preparations that go into these flights is perhaps not fully known even to those closely connected with the project. Each one is essentially similar in complexity to the launching of a satellite.

APPENDIX I

SKY-CAR FLIGHT 797

13 August 1958

O. C. Winzen & Capt. G. J. Schock

0730	Launch
0740	No communication with NCA-32.
0742	Radio off.
0744	Altitude 1400 feet.
0745	Radioed position to Minneapolis tower.
0750	OCW valved 2 seconds to maintain 1800 feet.
0800	Contact with NCA-31. Established no contact with NCA-32 or NCA-34.
0810	Started descent from 5000 feet at 50 ft/min. rate of descent.
0830	Called NCA-32 and 34 - no contact. Contact with NCA-31 - informed 34 has no radio - 31 still clearing at Fleming Field.
0900	Contact with NCA-32 and 31. Hensley not tracking. Dittmer following in his auto sans radio. Altitude 3800 feet - descending.
0930	Altitude 3500 feet. Contact with NCA-31 and 32 established.
0945	Passed Stillwater - 1 mile to the north.
0953	Two swallows inspecting balloon. Altitude 2600 feet.
1000	Contact with NCA-32 near marine (south.) Contact with NCA-31 - planning to send Dittmer and Hensley along soon. Altitude 2000 feet descending 50 ft/min.
1020	Approach and touchdown 10 miles north of Stillwater near St. Croix River - 15 lbs. ballast expended.
1030	Second touchdown and approach - 12 miles north Stillwater. 10 lbs. ballast expended.
1045	Passing over Osceola, Wisconsin on west side - 1800 feet altitude.
1100	Contact with NCA-32. Gave our ground speed of 20 mph to 32. Requested weather and instructions from Col. Simons if we should terminate flight about 2000 today and have Capt. Schock solo tomorrow if weather permits.

1130	Contact with NCA-32 weak. Will call again at 1200.
1200	Over Cushing, Wisconsin. NCA-32 on county road 16 on Minnesota side. Weather report will follow when reception better. Beginning ascent to 10,000 feet. 5 lbs. ballast after 30 seconds establishing rate of climb of 200 ft/min.
1208	Dropped another 5 lbs. ballast since rate of climb has stopped.
1220	Dropped 5 lbs. more ballast. Rate of climb established at 250 ft/min.
1230	Duluth forecast - via Lee Lewis. Clouds - scattered 12 K ft, 15 mi visibility, scattered rainshowers No. Minnesota thundershowers in afternoon. 8 knots surface winds. Watch shower activity closely. Terminate by 1800 in any event. NCA-32 on highway 95 at St. Croix beach crossing to Wisconsin side. 2nd tracking crew departed WRI.
1230	Position 5 mi. No. Taylors Falls, Wisconsin. Dumped 10 lbs. more ballast. Altitude 5000 feet.
1300	Dumped another 15 lbs. ballast at 6500 since rate of ascent had slowed to 200 ft/min. NCA-32 on way to Cushing on highway 36.
1330	Altitude 10,700 ft. Starting descent.
1346	Maximum altitude 11,800 ft. Balloon ascent slowed.
1400	Altitude 10,200 feet. Balloon slowing.
1415	10 miles east of Shell Lake. Altitude 9700 feet.
1435	No contact with NCA-32 or 31. South east of Shell Lake altitude 6000 feet.
1447	Cumulus clouds overhead beginning to burn off.
1450	Touchdown near Birchwood, Wisconsin.
1500	Touchdown near Stone Lake.
1525	Passing over Stone Lake, Wisconsin altitude 3200 feet.
1530	Touchdown at Stone Lake, Wisconsin.

1537 Entered light rain with rainbow.

1600 Passing 1/2 mile east of Hayward, Wisconsin.

1620 Contact with Cable unicom. Informed office of our altitude, etc. Got local wx forecast of 15 - 16 mph from 210^{o} -- 240^{o}.

1640 Passing over Cable to the west.
Ground speed 20 mph altitude 5000 feet.
Cable winds 208 at 12 knots.
Duluth wx
8 - 12 knots sw from 180^{o}. Thunderstorms after 2000 hours.

1700 First thunder heard 2 miles to west.
Approaching Grandview, Wisconsin. Asked Cable unicom for geography between our position and Ashland. Cable advises we land north of Mason.

APPENDIX II

O. C. WINZEN INJURIES

Fractures included the following:

1. Fracture of the right clavicle. Junction middle and upper thirds.

2. Fracture of right wrist and lower arm. Both radius and ulna - fracture of the radius and avulsion of the ulnar styloid.

3. Several rib fractures.
   Rib #6, right, midscapular line.
   Rib #4, left, midscapular line.

4. Two cracked and compressed vertebrae.
   Fractures lumbar vertebrae 1 and 2 with slight to moderate compression anteriorly.

5. Several broken vertebra processes.
   Fractures of the transverse processes of the second lumbar vertebra on the left and possibly the third lumbar on the right.

6. Dislocation of bone in right foot. Old compression of the tarsal navicular bone right foot.

(From letter dated 5 December, 1958 by Dr. Frank S. Babb, attending physician.)

APPENDIX III

IMPACT FORCES OF SKYCAR AND LANDING

The following is a determination of impact for the Sky-Car when it fell to the ground.

$$M \frac{dV}{dt} = Mg - \frac{CAeV^2}{2}$$

This equation relates the fall of a body through the atmosphere which offers resistance to its increasing velocity, V.

When the body hits the ground, it changes its velocity from V_f to O in a time, t, which is determined by the characteristics of the body. The actual solution can be obtained only by accurate experiment. However, with certain assumptions, an approximate solution can be obtained and an approximate g-force can be determined.

Assume:

(1) that the body free-fell from 100 feet.

(2) that the Sky-Car base (styrofoam) absorbed the impact and changed its vertical dimension by S inches.

These allow us to obtain the following results.

(1) V_f, speed of capsule when it hit the ground is given by

$$V_f = \sqrt{2 g S}$$

$$= \underline{80 \text{ ft/sec.}}$$

(2) $\frac{\partial}{\partial t} \left(\frac{1}{2} M V_f^2 \right) = Fg$, and solving $M \left(V_f - V_o \right) = M \bar{a}$.

Where M is the mass, V_e is equal to O, $\bar{a}$ is the average g-force of the impact, and t is total time of impact.

Now $t = \sqrt{\frac{2S}{a}}$, since $S = \frac{1}{2} \bar{a} t^2$ during impact.

Or $V_f = \sqrt{2aS}$

Or $\boxed{a = \frac{V_f^2}{2S}}$

S, is the change in the dimension of the Sky-Car base which absorbed the energy, $\left(\frac{1}{2} M V_f^2.\right)$

If, S is in inches

$$\bar{a} \text{ (g-force)} = \frac{80^2}{2. \frac{S}{12} \times 32} = \frac{1200}{S}$$

Now this represents the average g-force which acted on the body for the time, t.

Since S cannot be known for certain, a curve showing $\bar{a}$ vs. S is plotted on the accompanying graph. Also shown is Δt, the duration of impact.

In all probability the g-force during impact was over 100 g's for some 20 milliseconds. It can not be said for certain, but it is very likely that an average deceleration of 200 g's did result from the Sky-Car falling 100 feet, based on the assumptions stated above.

CURVE SHOWING AVERAGE G-FORCE DURING IMPACT OF SKY-CAR FLIGHT NO 797 VERSUS IMPACT TIME AND STYROFOAM DISPLACEMENT

a, d FORCE (100 g's)

6
5
4
3
2
1

← MOST PROBABLE RANGE →

4.2 | 6.25 | 8.4 | 10.6 | 12.5 | 16.8 | 20.8

Δt, IMPACT TIME (MILLISECONDS)

0 1 2 3 4 5 6 7 8 9 10

S, DIMENSION CHANGE (INCHES)

DWG NO 496340